PROGRAMMING

FOR THE

XEBEC 1200 SERIES

FLEXIBLE DISK CONTROLLER

MAY 5, 1977

TABLE OF CONTENTS

SECTION	DESCRIPTION	PAGE
6.	PROGRAMMING	6-1
6.1	Input/Output Instructions	6-1
6.1.1	Sector Format	6-1
6.1.2	I/O Instruction Summary	6-3
6.1.3	SKNB -- 6310 -- Skip if Not BUSY	6-5
6.1.4	SKNI -- 6311 -- Skip if Not Interrupting	6-5
6.1.5	SKNE -- 6312 -- Skip if No Error	6-5
6.1.6	LDMA -- 6313 -- Load Memory Address Register	6-6
6.1.7	LDCM -- 6314 -- Load Command Word Register	6-7
6.1.7.1	Unit Number (UN), Bits 0-2	6-8
6.1.7.2	Interrupts Enable (I), Bit 3	6-8
6.1.7.3	High Order Bit of Unit No. (HU), Bit 3	6-8
6.1.7.4	Diagnostic (D), Read/Write Preamble and CRC, Bit 4	6-8
6.1.7.5	Restore (R), Bit 5	6-11
6.1.7.6	Memory Field (MF), Bits 6-8	6-11

SECTION	DESCRIPTION	PAGE
6.1.7.7	Sector/Half Sector Transfer (S/H), Bit 9	6-11
6.1.7.8	Operation Code (OP),Bits 10-11	6-12
6.1.7.8.1	Read Operation (OP=0)	6-12
6.1.7.8.2	Write Operation (OP=1)	6-13
6.1.7.8.3	Check Operattion (OP=2)	6-14
6.1.7.8.4	Seek/No-Op (OP=3)	6-15
6.1.8	LDDA -- 6315 -- Load Disk Address Register	6-16
6.1.9	RDST -- 6316 -- Read Status Register	6-18
6.2	OS/8 System and Non-System Handlers	6-20
6.2.1	Programming Interface	6-20
6.2.1.1	Device Dependent Bits	6-21
6.2.1.2	Returns	6-22
6.2.2	Program Operation	6-22
6.2.2.1	Read, Write, Check Functions	6-22
6.2.2.2	Seek/No-Op Function	6-23
6.2.2.3	Write-Check Function	6-23
6.2.3	Booting	6-23
6.2.4	OS/8 Handler Modification	6-24
6.3	Formatting a Diskette	6-24
6.3.1	Diagnostic Program Formatting	6-25
6.3.2	FORMAT	6-26
6.3.3	Special Formatting Program	6-26

6. PROGRAMMING

The programming chapter describes the I/O instructions for users wishing to write their own drivers. The OS/8 System and Non-System Handlers are also described.

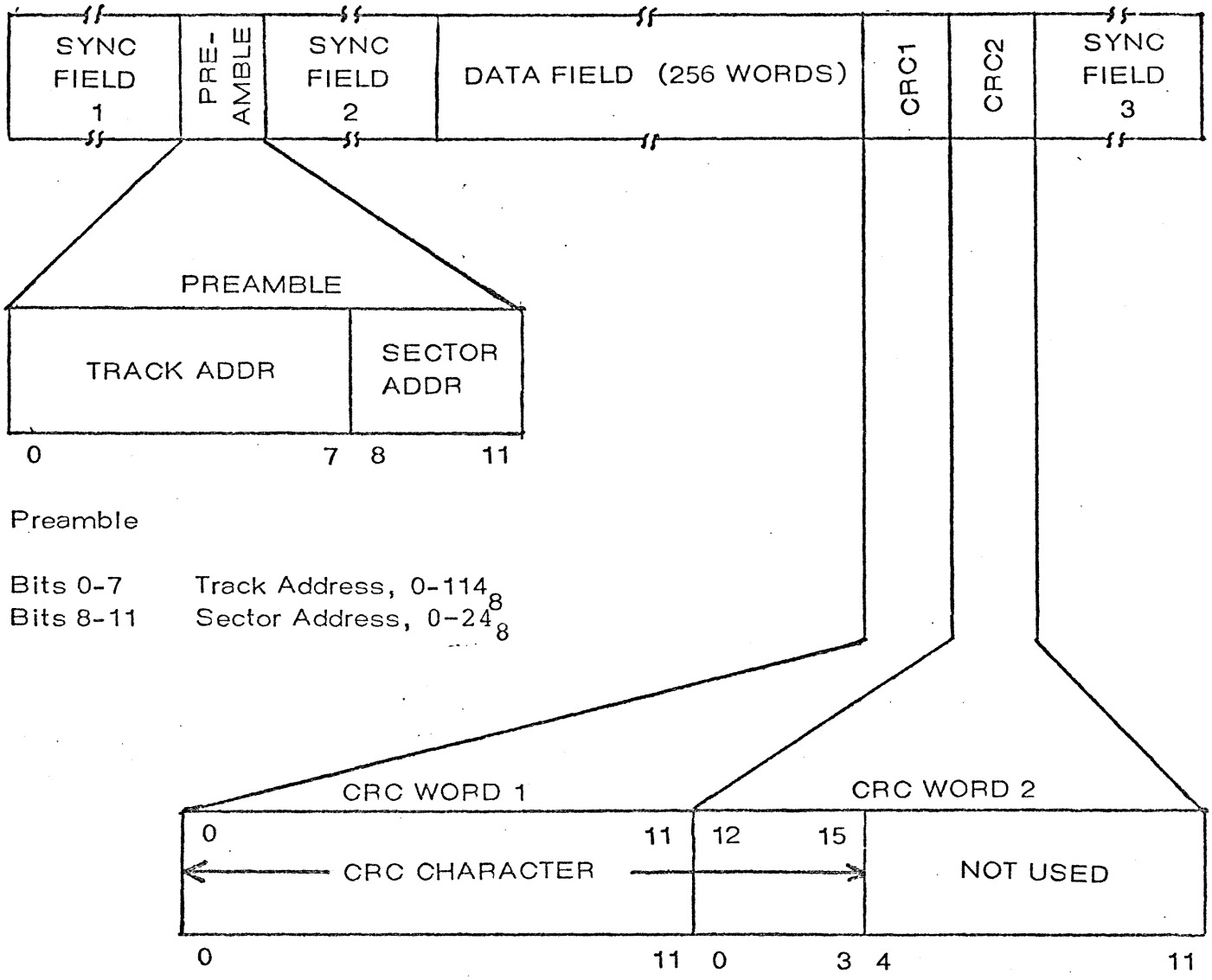
6.1 Input/Output Instruction

The I/O instructions control all the functions of the controllers. The instructions are summarized in this section and explained in greater detail in following sections.

6.1.1 Sector Format

Figure 6-1 shows the sector format. The portions of the sector available to the programmer are:

1. Preamble - The preamble is one word and consists of the track address and the sector address. The preamble is read and compared before each normal operation. The preamble may be written during a diagnostic operation.
2. Data Field - The data field is 256 words long.
3. CRC Field - The CRC Field contains the 16-bit CRC character in two 12-bit words. The CRC is generated by the controller during each write operation (except diagnostic operations) and is checked during each read and check operation.



Preamble

Bits 0-7 Track Address, $0\text{-}114_8$
Bits 8-11 Sector Address, $0\text{-}24_8$

CRC Word 1

Bits 0-11 High order 12-bits of CRC

CRC Word 2

Bits 0-3 Low order 4-bits of CRC
Bits 4-11 Not used

FIGURE 6-1 SECTOR FORMAT

Each diskette contains:

256 words per sector

20 sectors per track

77 tracks per diskette

6.1.2 I/O Instruction Summary

The detailed input/output machine instructions are summarized below and described in greater detail in the following sections. The standard device address assigned at the factory is 31_8. If desired, the address can be easily changed to any other 6-bit value by jumpers on the coupler card.

Mnemonic	Code*	Description
SKNB	6310	Skip if Not BUSY
SKNI	6311	Skip if Not Interrupting
SKNE	6312	Skip if No Error
LDMA	6313	Load Memory Address Register
LDCM	6314	Load Command Word Register
LDDA	6315	Load Disk Address Register
RDST	6316	Read Status Register

*These codes reflect the device address of 31_8 and will change if the device address changes.

Table 6-1

I/O Instruction Summary

Figure 6-2 shows the register summary for ease of reference.

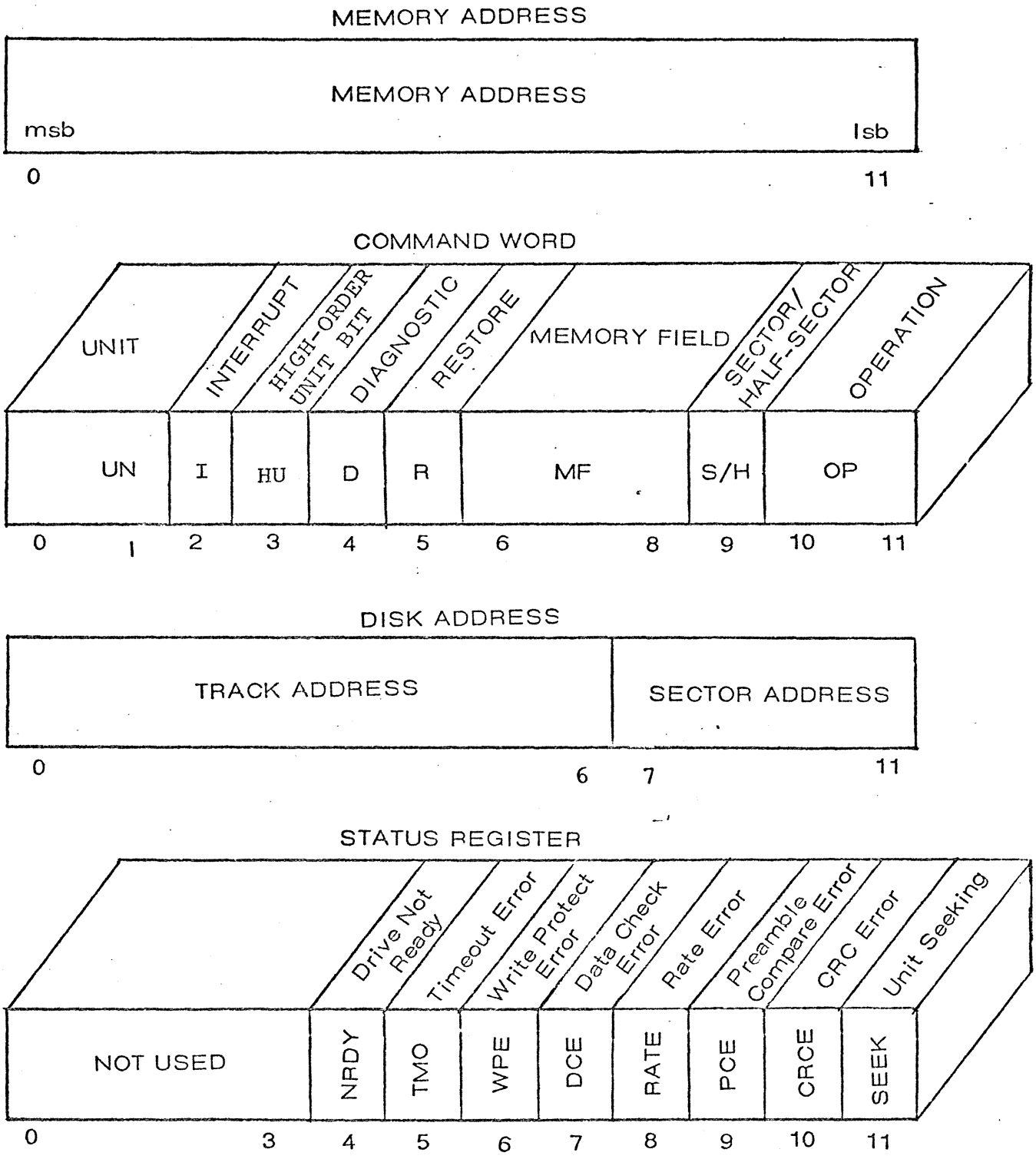


FIGURE 6-2 REGISTER SUMMARY

6.1.3 SKNB -- 6310 -- Skip if Not BUSY

If BUSY is 0 skip the next instruction, otherwise, do not skip. This instruction may be executed at any time. BUSY, a formatter flag, is set only when a read, write, or check operation is being performed; BUSY is reset when the operation is complete or when an error condition is detected. BUSY is also reset when the CLEAR switch is depressed.

6.1.4 SKNI -- 6311 -- Skip if Not Interrupting

Skips the next instruction if the controller is not interrupting. If the controller is interrupting no skip occurs, but the interrupt is cleared and disk interrupts are disabled. The interrupt occurs when BUSY is rest, after having been set by LDCM, and disk interrupts are enabled. The skip occurs if either BUSY is set or disk interrupts are disabled (I=0 in LDCM).

NOTE: Executing this instruction is the only way to disable/clear interrupts other than issuing I=0 in LDCM or depressing the CLEAR switch.

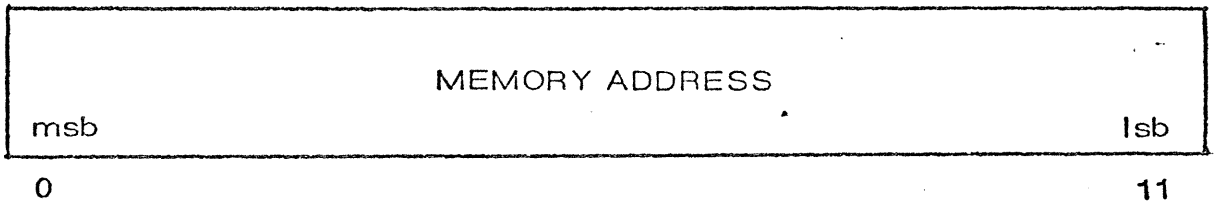
6.1.5 SKNE -- 6312 -- Skip if No Error

Skips the next instruction if no error condition is detected. The error condition is detected whenever any of the status indicators, except SEEK, is set.

BUSY should be tested (SKNB) before executing this command. All of the errors reset BUSY, thus, BUSY should not be set if an error bit is set.

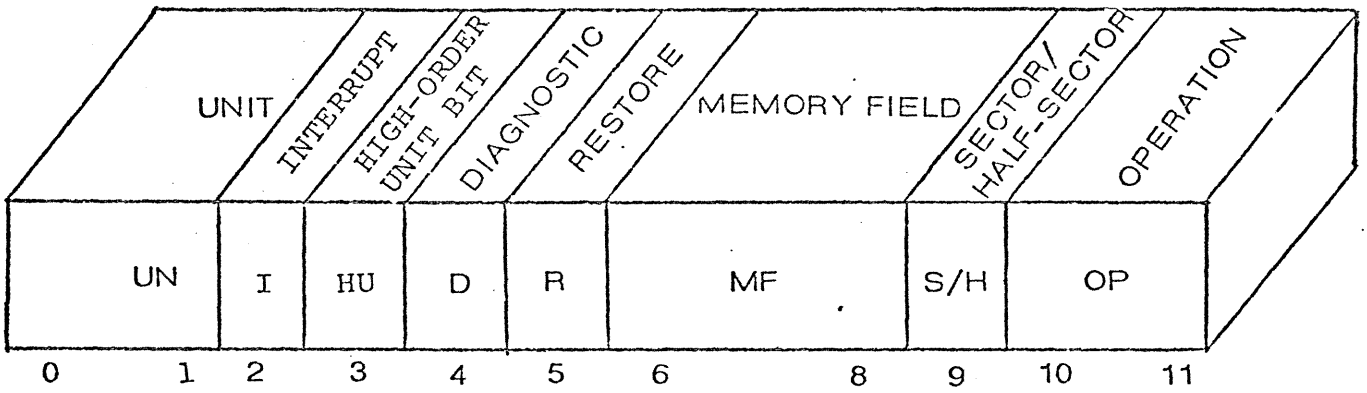
6.1.6 LDMA -- 6313 -- Load Memory Address Register

This command loads the controller's memory address register with the contents of the accumulator. The value loaded, MA, specifies the starting address of a buffer in the computer memory to be used by the controller during a write or read operation. After the operation is initiated, MA is incremented by the controller as successive words are transferred to or from memory. The memory address register is set to zero when the CLEAR switch is depressed.



6.1.7 LDCM -- 6314 -- Load Command Word Register

This instruction loads the controller's command register with the contents of the accumulator, clears certain controller status flags, sets BUSY, and then initiates the operation specified by the operation code. When the operation is completed, BUSY is cleared. If interrupts are enabled, an interrupt is generated when BUSY is reset. This instruction must not be executed while BUSY is set.



Bits 0 - 1	Unit Number (UN), 0 to 3
Bit 2	Interrupts Enable (1), 0 = disabled, 1 = enabled
Bit 3	High Order Bit of unit no, true for Units 4 - 7
Bit 4	Diagnostic (D), Read/Write Preamble and CRC
Bit 5	Restore to track 0 (R)
Bits 6 - 8	Memory Field Select (MF)
Bit 9	Sector/Half Sector Transfer (S/H), 0 = Sector transfer, 1 = half sector transfer
Bits 10 - 11	Operation Code (OP)

0 Read data from disk

1 Write data to disk

2 Check data on disk

3 Seek to a track

6.1.7.1 Unit Number (UN), Bits 0 - 1

The unit number selects the disk unit on which the requested operation will be performed.

6.1.7.2 Interrupts Enable (1), Bit 2

If this bit is set, an interrupt is generated when BUSY is reset. BUSY is reset at the completion of an operation, or as the result of an error condition. A Seek/No-Op does not generate an interrupt. The computer does not detect the interrupt unless system interrupts are enabled with an ION instruction (6001).

6.1.7.3 High Order Bit of Unit No (HU), Bit 3

This bit, in combination with bits 0 - 2 allows up to 8 units to be addressed. This bit is always 0 for Units 0 - 3, and always 1 for units 4 - 7.

6.1.7.4 Diagnostic (D), Read/Preamble and CRC/Write CRC, Bit 4

If this bit is set when a read operation (OP=0) is requested, the preamble, 256 words of data, and the two CRC words are transferred into the PDP-8 memory. If this bit is set when a write operation (OP = 1) is requested, 256 words

of data, and two words of CRC are written on the disk. Reading with this bit set will ignore the half sector transfer bit. Writing with this bit and the half sector transfer bit on will format the entire track currently specified. Figure 6-3 shows the memory map (starting at MA) before a diagnostic write operation or after a diagnostic read operation.

The CRC is generated by the program in the format shown in Figure 6-1, for a diagnostic write.

If this bit is set with a check operation (OP = 2), the preamble, 256 data words, and the two CRC words are compared, 259 words total. When used with the Seek/No-Op operation (OP = 3), this bit has no effect.

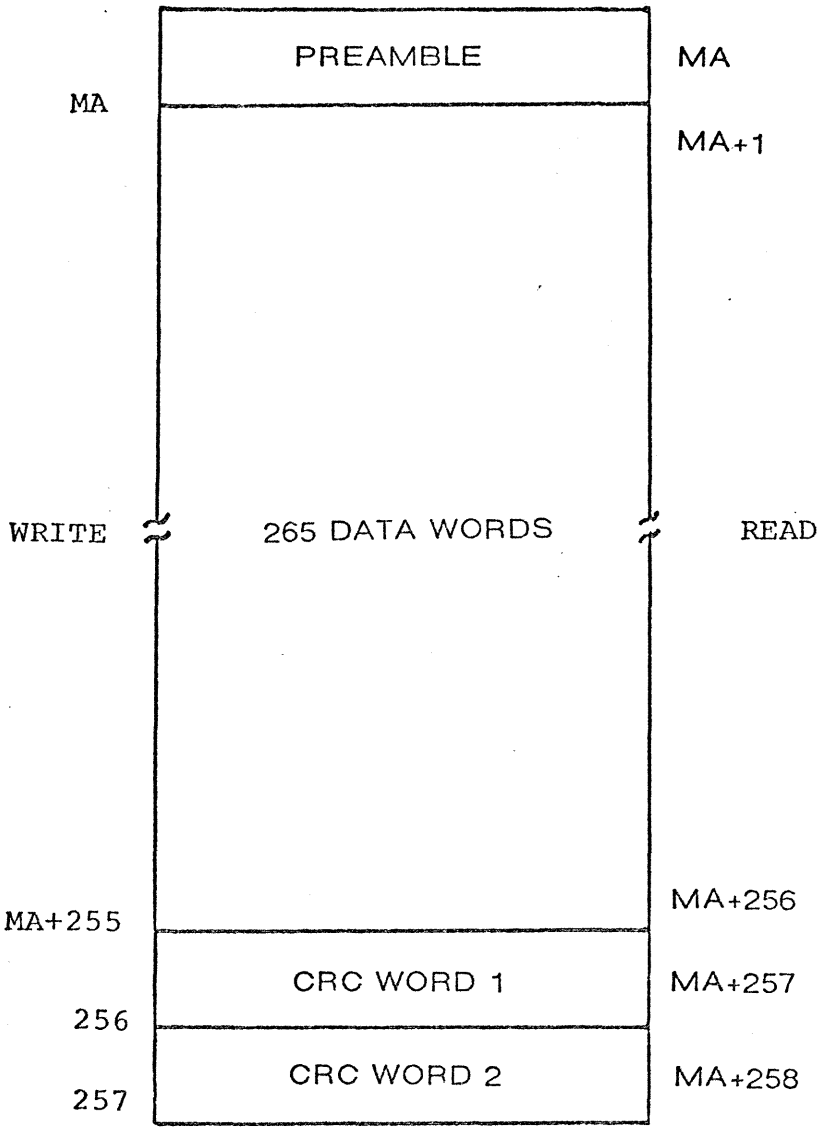


FIGURE 6-3 MEMORY BEFORE A DIAGNOSTIC WRITE OR AFTER A DIAGNOSTIC READ

Preamble is not written on diagnostic write, but is read on diagnostic read.

6.1.7.5 Restore (R), Bit 5

If this bit is set, the selected unit automatically seeks to track 0. Any additional seeking, as specified in the Disk Address Word, is then performed. BUSY is set if the rest of the command word requires it, otherwise, it is unaffected. The unit should be restored after Preamble Compare Errors (PCE) and Timeout Errors (TMO) to reposition the unit to a known track location.

6.1.7.6 Memory Field (MF), Bits 6 - 8

This field is used to specify the memory field of the memory address (MA).

6.1.7.7 Sector/Half Sector Transfer (S/H), Bit 9

If this bit is set for a read or write operation a half sector of data is transferred as follows:

Write	A half sector of data is transferred starting at MA and the rest of the sector is padded with zeros.
Read	A half sector of data is read into a buffer starting at MA.

Half sector operations are incompatible with reading the CRC character and should not be attempted. Combining the half-sector bit with a diagnostic write will format the current track.

6.1.7.8 Operation Code (OP), Bits 10 - 11

One of four operations may be specified in this field:

0 Read

1 Write

2 Check

3 Seek/No-Op

6.1.7.8.1 Read Operation (OP = 0)

This operation causes the controller to input from the selected unit directly to the computer memory. Either one sector (S/H=0) or one-half sector (S/H-1) of data is read from the sector specified by the Disk Address Word into a buffer beginning at MA in the memory field MF. Data words from the specified sector are input to consecutive memory locations beginning at the initial values of MA and MF.

When the command word is loaded, BUSY is set; a seek to the track given in the Disk Address word is initiated; and the SEEK indicator of the Status Word is set until the seek is completed. If R is set, the read/write head on the specified unit is first restored to track 0. The seek to the selected track is then initiated. In either case the SEEK indicator remains set until head motion stops.

During each read operation, the sector preamble is automatically hardware compared and the CRC is calculated over each data word in the sector, regardless of how many

words are transferred. The CRC is then hardware compared against the CRC generated during the last write operation on the sector.

BUSY is set when the operation is initiated and reset after all the words specified by the S/H bit have been transferred, and the CRC has been compared. If I has been set in the command word, an interrupt is generated at the time that BUSY is reset.

The use of D with this operation is discussed in the section, Diagnostic (D), Read/Write Preamble and CRC, bit 4.

6.1.7.8.2 Write Operation (OP = 1)

This operation causes the controller to output data from computer memory to the selected unit. Either one sector (S/H = 0) or one-half sector (S/H = 1) of data is written from a buffer beginning at MA in MF to the sector specified by the Disk Address Word. Data words are transferred to the sector from consecutive memory locations beginning at the initial values of MA and MF.

When the command word is loaded, BUSY is set; a seek to the track specified in the Disk Address Word is initiated; and the SEEK indicator of the Status Word is set until the seek is completed. If R is set, the read/write head on the specified unit is first restored to track 0. The seek to the selected track is then initiated. In either case the SEEK indicator remains set until head motion stops.

During each write operatsion the CRC is calculated over each data word of the sector, regardless of the number of words transferred. If a half sector of data is written the remainder of the sector is automatically padded with zeros and the CRC is still claculated over each word of the sector.

BUSY is set when the operation is initiated and reset after all the words specified by the S/H bit have been transferred, and the CRC character has been generated. If I is set in the command word, an interrupt is generated at the time BUSY is reset.

The use of D with this operation is discussed in section 6.1.7.4.

6.1.7.8.3 Check Operation (OP = 2)

This operation causes the controller to compare the data on the disk, specified by the Disk Address word, with the data in memory beginning at MA in memory field MF. If the data does not match the Data Check Error (DCE) is set. The preamble and CRC words are checked in the normal manner, but not compared as part of the data.

If D is set with this command, the preamble, 256 data words, and the two CRC words (259 words in all) are compared. The memory starting at MA in memory field MF must contain all

259 words to be compared. If any word does not compare the Data Check Error (DCE) is set. In addition to the compare, the preamble and CRC words are checked in the normal manner.

When the command word is loaded BUSY is set; a seek to the track specified by the Disk Address Word is initiated; and the SEEK indicator of the Status Word is set until the seek is completed. If R is set, the read/write head of the unit specified is first restored to track 0. The seek to the specified track is then initiated. In either case the SEEK indicator remains set until head motion stops.

BUSY is set when the operation is initiated and reset after the sector has been checked. If I is set in the command word, an interrupt is generated when BUSY is reset.

6.1.7.8.4 Seek/No-OP (OP = 3)

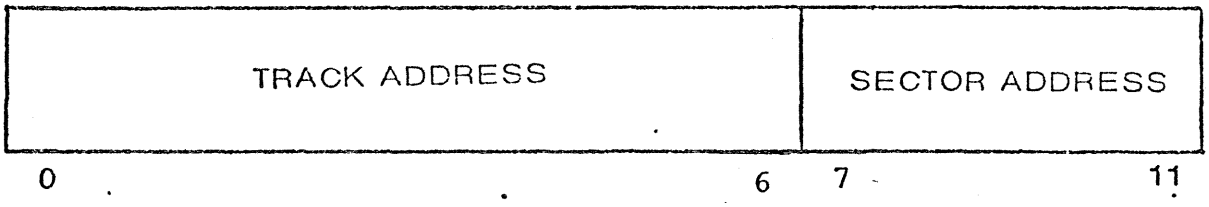
This operation causes the controller to select the unit specified and to position that unit to the track specified by the Disk Address Word.

When the command is loaded a seek to the track specified as initiated and the SEEK indicator of the Status Word is set until the seek is completed. If R is set, the read/write head of the specified unit it first restored to track 0. The seek to the specified track is then initiated. In either case the SEEK indicator remains set until head motion stops.

This operation is used primarily as a unit select operation and to effect a restore.

6.1.8 LDDA -- 6315 -- Load Disk Address Register

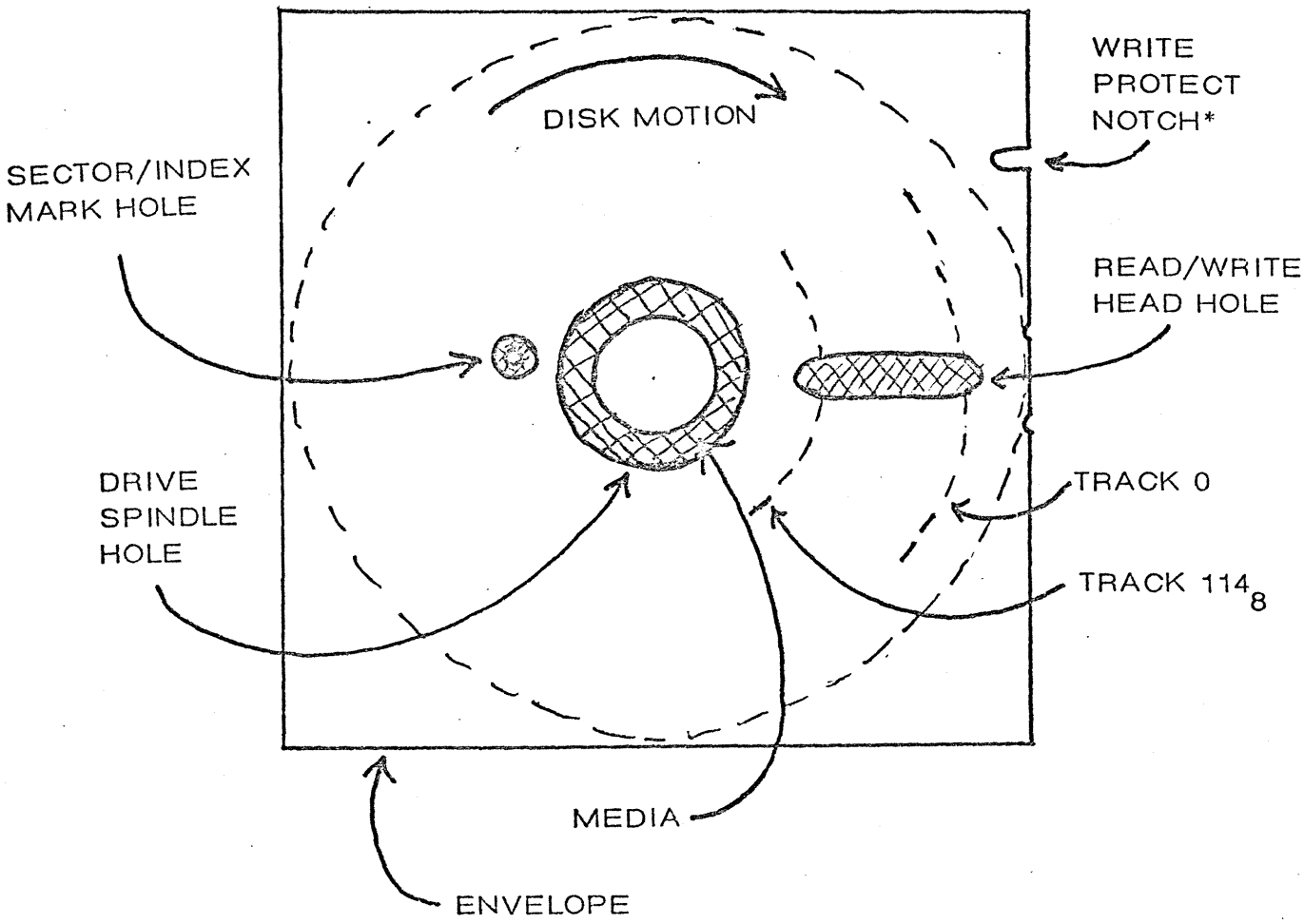
This instruction loads the Disk Address Register of the controller.



Bits 0 - 7	Track Address	There are 77 tracks on each diskette. They are numbered from 0 to 114_8.
Bits 8 - 11	Sector Address	There are 20 sectors per track. They are numbered 0 to 24_8.

Figure 6-4 is a drawing of a diskette and shows the relative locations of tracks 0 and 114_8 as well as the physical features.

Physically the sector numbers are consecutive around the disk.

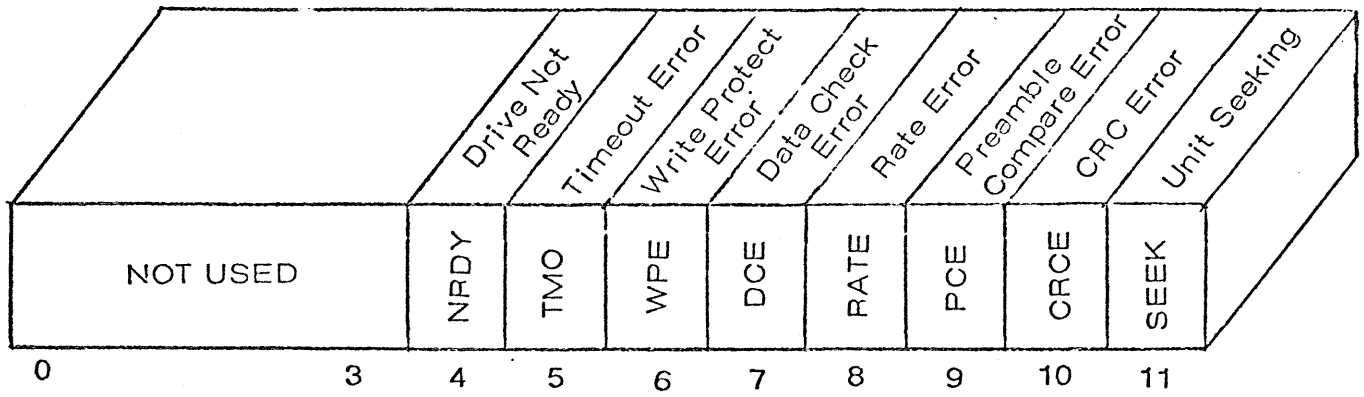


*The WRITE PROTECT NOTCH is used only when the Write Protect option of the drive is used. Otherwise, a switch on the unit designates a write protected unit.

FIGURE 6-4 DISKETTE

6.1.9 RDST -- 6316 -- Read Status Register

This instruction loads the accumulator with the contents of the controller's status register. The status indicates the state of the currently selected unit and operation or the operation just terminated. BUSY must be tested (SKNB) and found clear before executing this instruction. This instruction must not be executed if BUSY is set. All of these bits, except SEEK, will reset BUSY when they are set.



Bits 0 - 3	Not Used
Bit 4	Not Ready (NRDY)
Bit 5	Timeout Error (TMO)
Bit 6	Write Protect Error (WPE)
Bit 7	Data Check Error (DEC)
Bit 8	Rate Error (RATE)
Bit 9	Preamble Compare Error (PCE)
Bit 10	CRC Error (CRCE)
Bit 11	Unit Seeking (SEEK)

STATUS INDICATORS

BIT	MNE	NAME	SET BY	CLEARED BY	TERMINATES
4	NRDY	Not Ready	Specified unit indicates NOT READY; not plugged in, not up to speed, or no diskette in place.	Correct condition	BEFORE
5	TMO	Timeout Error	Operation timed out (2.5 sec) illegal track or hardware malfunction	Correct LDDA, and LDCM with R=1, or correct malfunction	BEFORE
6	WPE	Write Protect Error	Tried to write on write protected unit or diskette.	Next LDCM	BEFORE
7	DCE	Data Check Error	Check operation detected difference between data on disk and data in memory	Next LDCM	AFTER
8	RATE	Rate Error	Data transferred improperly, a word of data was too late for transfer	Next LDCM	DURING
9	PCE	Preamble Compare Error	Preamble read does not match Disk Address word	LDCM with R=1	BEFORE
10	CRCE	CRC Error	CRC calculated during read or check operation is different from CRC last written on sector	Next LDCM	AFTER
11	SEEK	Unit Seeking	Selected unit is physically seeking	Seek Completes	N/A

Table 6-2 lists all the status indicators. Errors marked as indicating termination before data transfer indicate that no data has been transferred. Errors that occur during transfer (RATE) will terminate the transfer. Data may be lost when the operation is terminated. Errors that occur after data transfer indicate that the data may be faulty.

6.2 OS/8 System and Non-System Handlers

A handler is provided which may be used as an OS/8 System handler or a non-system handler. The handler is descrbied in the following sections. An OS/8 key-in bootstrap is described. Finally, a listing of the handler is supplied.

The handler is inserted into the system with BUILD, as described in the OS/8 Handbook, the OS/8 Software Support Manual (DEC-S8-OSSMB-A-D), and the OS/8 Handbook Addendum #2 (DEC-S8-OSHBA-A-DN2).

6.2.1 Programming Interface

The system handler has a 'SYS' entry point and two sets of non-system entry points, the 'D' and 'X' device entry points. The compatible non-system handler has the 'D' and 'X' entry points only. Otherwise, it is identical.

The 'D' devices and the 'X' devices refer to the same physical units. The handler operation is identical except that a write operation through the 'X' entry results in a write of all blocks, followed by a check of all blocks specified.

The calling sequence conforms to the OS-8 device handler requirements (OS/8 Software Support ;Manual, Chapter 5). The available device dependent bits (bits 9-10) of the function word have been assigned meanings which allow additional capability to software executing under OS/8.

6.2.1.1 Device Dependent Bits

Bit 9 - Diagnostic Mode — This bit is used to set bit 4 of the command word. When set, the preamble, 256 data words, and the two CRC words will be transferred or checked depending on the operation.

Bit 10 - Auxiliary Function — This bit is used to set bit 10 of the command word. When clear, the function is a read or write, depending on the sign bit of the function word. When set, the function is a check if the sign bit is zero and a seek only if the sign bit is one.

6.2.1.2 Returns

The handler returns to the calling program at the normal return if no uncorrectable errors were encountered. MQ contains the command word used for the last command executed. AC contains zero if no errors were detected.

The handler returns to the calling program at the error return if an uncorrectable error is encountered. As above, MQ contains the command word for the last command attempted and AC contains -1.

6.2.2 Program Operation

6.2.2.1 Read, Write, Check Functions

The read, write, and check functions are executed as loops which transfer or check successive sectors from the continuous memory locations specified. If the specified page count is odd, the half sector flag is set for the final operation. If the specified page count is zero, 40_8 pages are transferred or checked.

After each operation, the status is checked. If a correctable error is detected, the operation is retried, up to three times per sector, after restoring.

6.2.2.2 Seek/No-Op Function

The seek/no-op function is initiated and the status is checked immediately. Control is returned to the caller while the seek is in progress. A subsequent driver call for the same unit will automatically wait for the week to complete.

6.2.2.3 Write-Check Function

The write-check function is performed by issuing a normal write operation to one of the 'X' entry points. The function is implemented as a write, all pages, followed by a check, all pages.

6.2.3 Booting

The handler may be bootstrapped with the following OS/8 Key-In Bootstrap.

LOCATION	CONTENTS	INSTRUCTION
00015	7200	CLA
00016	6313	LDMA
00017	6315	LDDA
00020	6314	LDCM
00021	6310	SKNB
00022	5021	JMP

Operating instructions:

1. Key in program.
2. LOAD ADDRESS 15.
3. LOAD MEM. FIELD 0.
4. Depress CLEAR and CONTINUE.

6.2.4 OS/8 Handler Modification

The handler program is supplied in source format so that it may be easily tailored to the requirements of the individual installation. Six assembly parameters are defined on the first page of the source. By modifying these parameters system and non-system handlers for any number of units can be generated.

6.3 Formatting a Diskette

A diskette must be formatted before it can be used for normal read, write and check operations. To format a diskette each sector must have:

Correct Preamble — Every normal read, write and check operation reads the preamble and hardware compares it with the Disk Address word. They must match before the operation is performed. The preamble consists of the track address and the sector address as shown in Figure 6-1.

256 Data Words	The data words are set to a worst case data pattern when a diskette is formatted.
CRC Words	Two words containing the CRC character, as shown in Figure 6-1, must also be written.

Diskettes may be formatted by using one of three techniques. The techniques are:

1. Use the Diagnostic Program.
2. Use the system program, 'FORMAT'.
3. Write a special format program.

6.3.1 Diagnostic Program Formatting

The Diagnostic Program may be used to format disks. Its use is described in the Diagnostic chapter.

6.3.2 'FORMAT'

A formatting program, called FORMAT, is supplied with the system to allow formatting of diskettes without the use of the Diagnostic Program. It will format diskettes on Unit 1, using a base device address of 31. If either of these needs to be changed, the source may be changed and the program re-assembled. The program is run under OS/8.

The general procedure for using FORMAT is:

1. Run OS/8.
2. Load a diskette to be formatted into Unit 1.
3. Enter the command: R FORMAT.
4. FORMAT will return to OS/8 when the diskette is formatted. If an error occurs, FORMAT will halt. The address of the halt will determine the error.

6.3.3 A listing of FORMAT is included in this chapter.

Special Formatting Program

If the user desires to write a special formatting program, the FORMAT program will provide an understanding of the general procedure. In short, every track must be formatted and then every sector must be checked to insure correct formatting.